2. Array Calculation - Solid Angle Method

In the case of small numbers of units at large separation distances, the solid angle method may be used to determine a conservative safe array. The solid angle method is quite tedious for large arrays even if the units are identical. In this method the total fractional solid angle of all surrounding units seen by the most reactive unit, usually the most centrally located, the k-effective of the central unit when isolated, and the probability of neutrons escaping the units are used to determine the k-effective of the array.

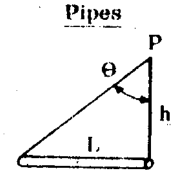
The solid angle, Ω (in steradians), or fractional solid angle, Ω_f, which is $\Omega/4\pi$, for cylinders and slabs may be calculated by the equations:

FORMULAE

General

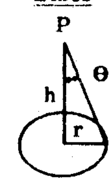
$$\Omega = \frac{\text{cross-sectional area}}{(\text{separation distance})^2}$$

Pipes



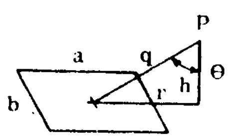
$$\Omega = (d/h) \sin \Theta$$

Discs

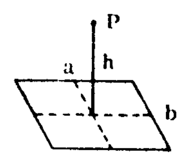


$$\Omega = 2\pi (1 - \cos \Theta)$$

Planes



$$\Omega = (ab/q^2) \cos \Theta$$

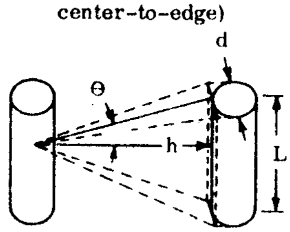


$$\Omega = 4 \sin^{-1} \frac{(a/2)(b/2)}{\sqrt{(a/2)^2 + h^2}\sqrt{(b/2)^2 + h^2}}$$

APPLIED METHODS

Cylinders

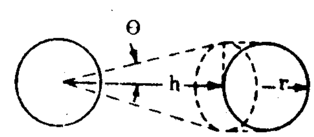
(Reduce to planes center-to-edge)



$$\Omega = (2d/h) \sin \Theta$$

Spheres

(Reduce to discs center-to-edge)



$$\Omega = 2\pi (1 - \cos \Theta)$$

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The fractional solid angle between identical spheres, slabs and cylinders may also be obtained from curves (pp. V.D.1-1, -2, -3) taken from Reference 3. However, an examination of the data in Table IV indicates nonconservative results when these curves are used with less than a separation of 2 diameters between units. The solid angle calculated by the use of equation (b) gives conservative answers.

The following equation[3] may be used to calculate the k-effective of regular arrays of identical units:

$$k_a = \frac{k_u}{1 - \left[(1-U) \sum (q_i \Omega_{fi})\right]} \qquad \text{(d)}$$

where

$(1-U)$ is the probability that fission neutrons will escape before being thermalized.

Ω_f is the fractional solid angle subtended at the central-most unit by the i-th unit of the array.

q_i is the flux weighting factor for the i-th unit of the array. For identical cylinders in air, $q_i = p_i$ where p_i is a weighting factor to Ω_i. For each unit in the array, p is based upon the neutron flux at that point of the array. Formulas for determining p are presented in Table II. For small arrays, a conservative solution may be obtained by considering $p_i = q_i = 1$.

k_a is the k-effective of the array.

k_u is the k-effective of the unit.